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Experimental investigation on involvement of Bio-Enzyme in concrete with replacement of cement with GGBS

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Abstract - *The technology for mixed concrete is currently advancing quickly, and numerous additional materials are being applied to create concrete with the required properties. Adding a chemical, like an entraining additive, or reducing water in the form of synthetic or organic materials is one method to enhance the quality of the concrete mix. In order to determine the ideal amount of bio-enzyme in concrete to boost its strength, bio-enzyme is added to five concrete mixtures that will be compared to regular concrete. Concrete mixes M30, M35, and M40 will be made with bio-enzyme 500 ml/□3, 600 ml/□3, 650 ml/□3 & GGBS of 5% to 15% as part of the current investigation. Compression, split tensile, and workability tests will be conducted.*

Every potential way to reduce CO2 emissions is being explored in this period of massive global warming, and one of the main emissions occurs during the cement-making process. Many materials, including fly ash, GGBS, silica fume, wollastonite, and waste glass powder, are utilized in place of some cement in order to address this issue. Environmental pollution can be decreased by partially substituting ground granulated blast furnace slag for cement.

Key Words: Fresh Concrete Test, Hardened Concrete Test, Workability, Split Tensile Strength, Durability Test(HCL).

1. INTRODUCTION

Portland cement is commonly regarded as the main component of concrete, which is among the most frequently utilized construction materials. The widespread use of concrete as a building material is driven by the infrastructure advancements resulting from rampant urbanization and industrial development. Cement production is expected to grow from around 1.5 billion tons in 1995 to 2.5 billion tons by 2015. Globally, concrete is utilized in the construction of highways, bridges, buildings, runways, sidewalks, and dams. Given the necessity of cement in construction, it has a strong connection to the economy. Projections indicate that cement production will rise from 2.55 billion tons in 2006 to between 3.7 and 4.4 billion tons by 2050, reflecting an annual growth rate of 2.5 percent.

1.1 Bio-Enzyme

- A natural, non-toxic, non-flammable, and non-corrosive liquid enzyme formulation derived from vegetable extracts, enzymes improve the engineering properties of the soil **.**
- Bio Enzyme, often referred to as Garbage Enzyme or Fruit Enzyme, is a versatile natural cleaner created from waste or the peels of fruits and vegetables, mainly citrus. Terrazyme is an alternative designation for it.
- From a chemical perspective, the bio-enzymes consist of a combination of complex organic compounds, such as proteins, salts, and other naturally occurring substances produced by the bacteria or yeast that we will utilize to produce them.
- Bio-enzymes are organic, biodegradable materials that are applied as additives to enhance soil. A liquid extract obtained from fruits and vegetables, bio-enzyme is organic in composition. It enhances the strength and durability of concrete. Dr. Rosukun Poompanvong is involved in bio-enzyme research and development in Thailand.

1.2 GGBS

- GGBS (Ground Granulated Blast-furnace Slag) is recognized as one of the environmentally friendly construction materials. Its raw material is a very particular slag that is a byproduct from the process of manufacturing iron in blast furnaces.
- The production of GGBS makes use of all the slag and generates no significant waste stream. Ground Granulated Blast-furnace Slag is a cement-like substance primarily utilized in concrete and is a byproduct from the operation of blast furnaces that produce iron.
- The rapid cooling enhances the cementitious characteristics and results in granules resembling coarse sand. This granulated slag is then dried and milled into a fine powder.

1.3 HCL

- Using hydrochloric acid (HCL) in concrete durability testing is part of acid resistance testing, which evaluates how concrete withstands aggressive chemical environments-especially relevant for industrial floors, sewage systems, or chemical plants.
- Concrete is alkaline in nature due to calcium hydroxide ($Ca(OH)_2$) and other hydration products. Acids like

HCL react with these alkaline components and degrade the concrete matrix.

2. Material And Methodology

2.1 Fine Aggregate (IS 2386 Part-1)

Table.1 Properties of Fine Aggregate

Properties	Sand
Sieve analysis	Zone II
Fineness modulus	2.871
Specific Gravity	2.64
Water Absorption	1.77
Bulk Density	1.62 (Loose) 1.76 (Compacted)

2.2 Coarse Aggregate (IS 383-1987)

Table.2 Properties of Fine Aggregate

Properties	20mm	10mm
Specific Gravity	2.88	2.99
Water Absorption	1.46%	0.29%
Aggregate Impact Value	9.21%	9.33%
Aggregate Crushing Value	11.75%	9.98%
Flakiness Index	10.89%	25.26%
Elongation Index	6.84%	7.66%
Bulk Density	1.657 (Loose) 1.75 (Compacted)	1.53 (Loose) 1.68 (Compacted)

2.3 Bio-Enzyme

Table.3 Properties of Bio-Enzyme

Properties	Value
PH Value	4.4
Specific Gravity	1.08
Solubility in water	Infinite
Odour	Characteristic odour
Flammability	Inflammable
Colour	Dark Brown

2.4 Mix Design (IS 10262-2019)

- For M30 Grade of Concrete Mix

Table.4 Mix Proportion (per cubic meter)

Water	Cement	FA	CA	Total
197.16	448.09	771.31	1082.53	2499.09
0.43	1.00	1.72	2.42	5.57

- For M35 Grade of Concrete Mix

Table.5 Mix Proportion (per cubic meter)

Water	Cement	FA	CA	Total
157.60	405	791.37	1181.49	2535.46
0.39	1.00	1.95	2.92	6.26

- For M40 Grade of Concrete Mix

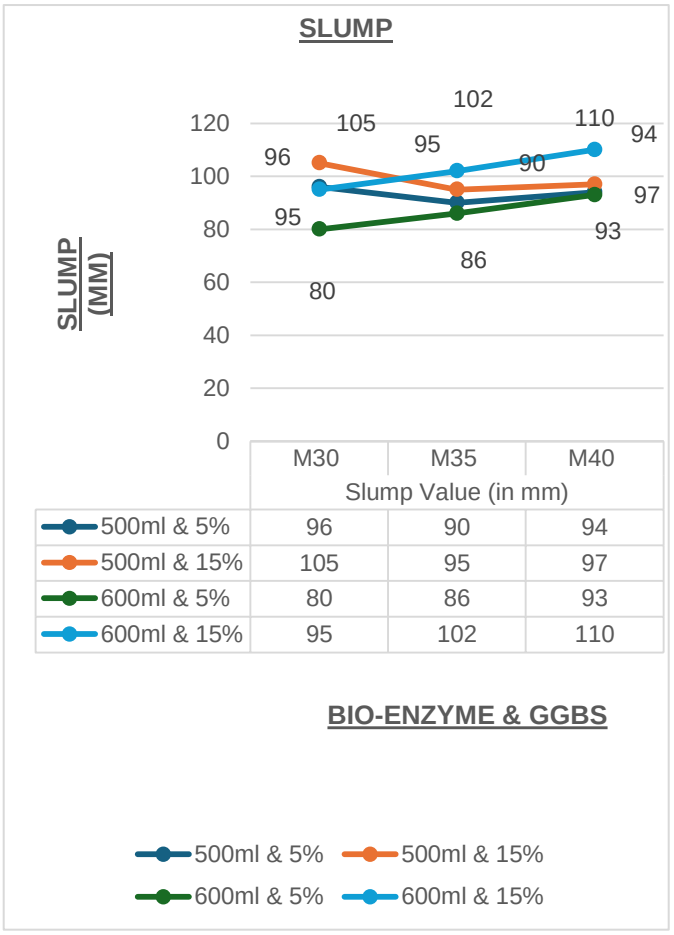
Table.6 Mix Proportion (per cubic meter)

Water	Cement	FA	CA	Total
153.57	437	816.26	1125.53	2532.36
0.35	1.00	1.87	2.58	5.80

3. RESULTS

3.1 Workability

- The concrete slump test measures the Workability of fresh concrete before it sets.
- It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows.
- The slump test is used for the measurement of a property of fresh concrete as per IS: 1199 - 1959.



	M30	M35	M40
	Slump Value (in mm)		
500ml & 5%	96	90	94
500ml & 15%	105	95	97
600ml & 5%	80	86	93
600ml & 15%	95	102	110

Chart -1: Slump Value Comparison

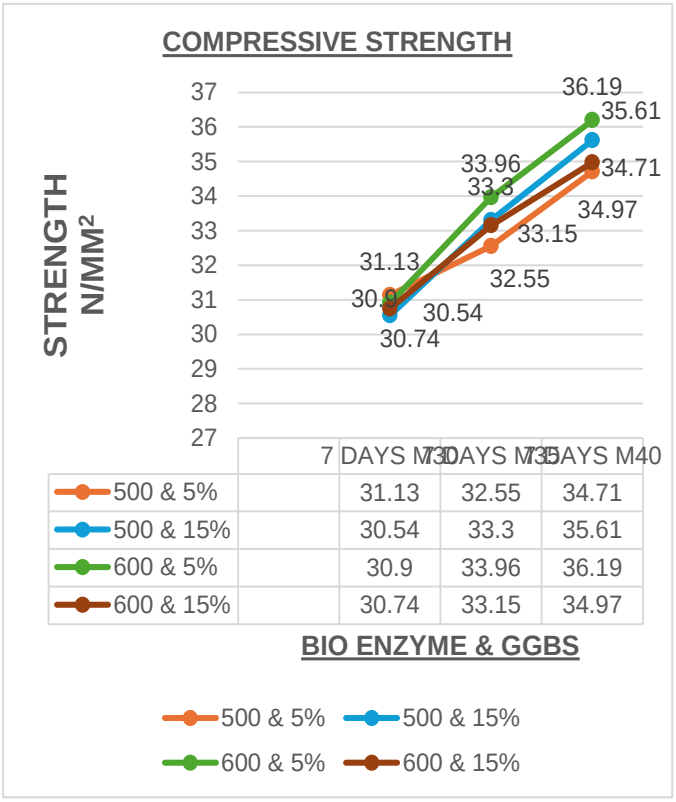
3.2 Compressive Test Results

- Determination of compressive strength using by cube where size of cube specimen is 150×150×150 mm and this test was performed on a 2000 KN capacity compression testing machine.
- Bureau of Indian Standards suggests that the compressive strength of concrete be considered as the basis for determining all properties and studying response of concrete. As such more emphasis was given on this test. The compressive strength of concrete was evaluated at the age of 7 days, 14 days and 28 days.
- The compressive strength of cube specimen is calculated using the following formula:

$$\sigma = P/A$$

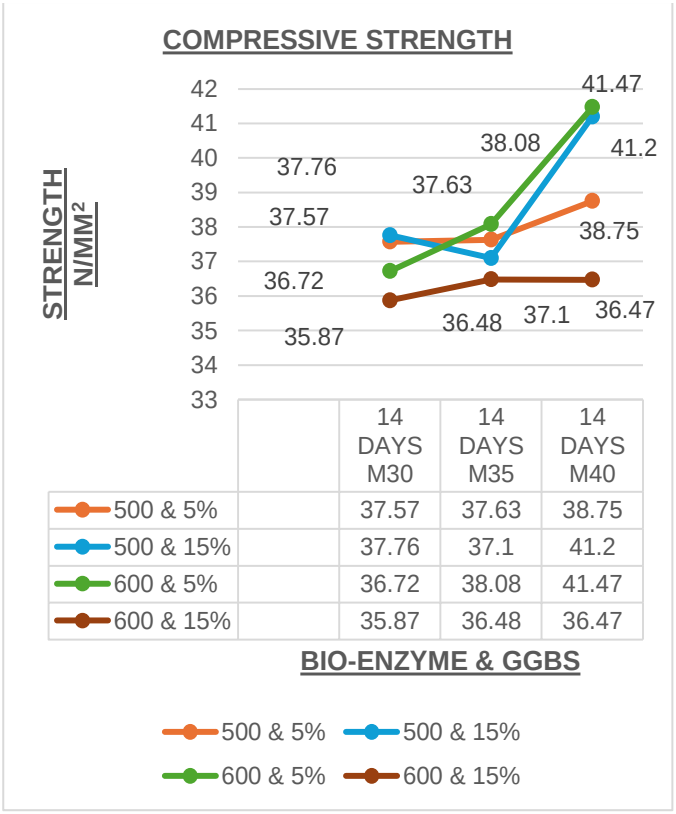
Where, P = failure load

A = cross sectional area of cube in mm



	7 DAYS M30	7 DAYS M35	7 DAYS M40
500 & 5%	31.13	32.55	34.71
500 & 15%	30.54	33.3	35.61
600 & 5%	30.9	33.96	36.19
600 & 15%	30.74	33.15	34.97

Chart -2: Compressive Test Result for 7-days



	14 DAYS M30	14 DAYS M35	14 DAYS M40
500 & 5%	37.57	37.63	38.75
500 & 15%	37.76	37.1	41.2
600 & 5%	36.72	38.08	41.47
600 & 15%	35.87	36.48	36.47

Chart -3: Compressive Test Result for 14-days

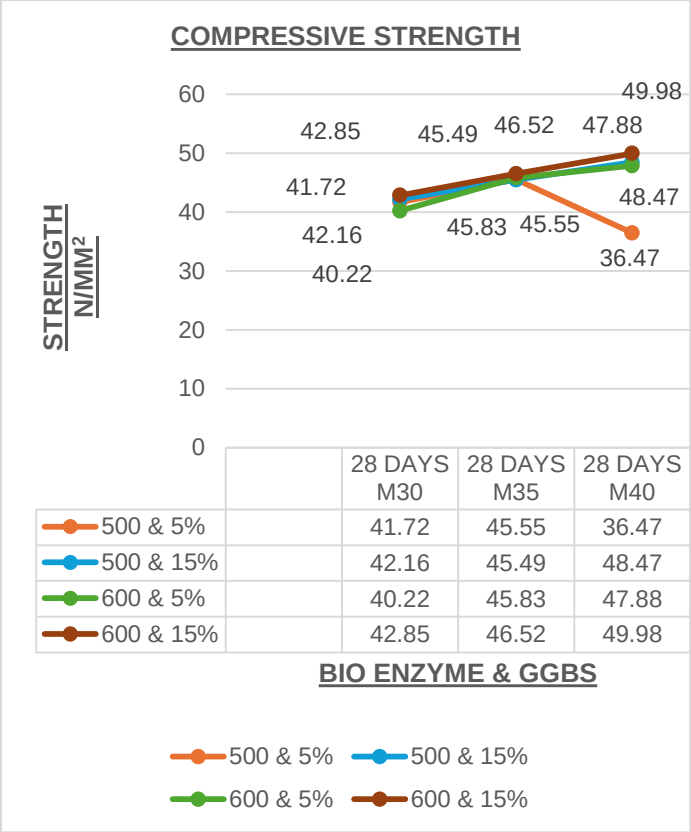


Chart -4: Compressive Test Result for 28-days

3.3 Split Tensile Test Results

- To determine the split tensile strength of concrete, cylindrical specimens measuring 150 mm in diameter and 300 mm in height were cast and tested at 28 days of age.
- The split tensile strength of concrete at 28 days was evaluated.
- The results obtained were compared with the concrete's compressive strength at the same age. During the testing procedure, the compression load will be applied along the two opposite axial lines.

Tsp = 2P/ 3.14 DL
Where, P = Applied Load
D =Diameter of the Specimen

L = Length of the Specimen

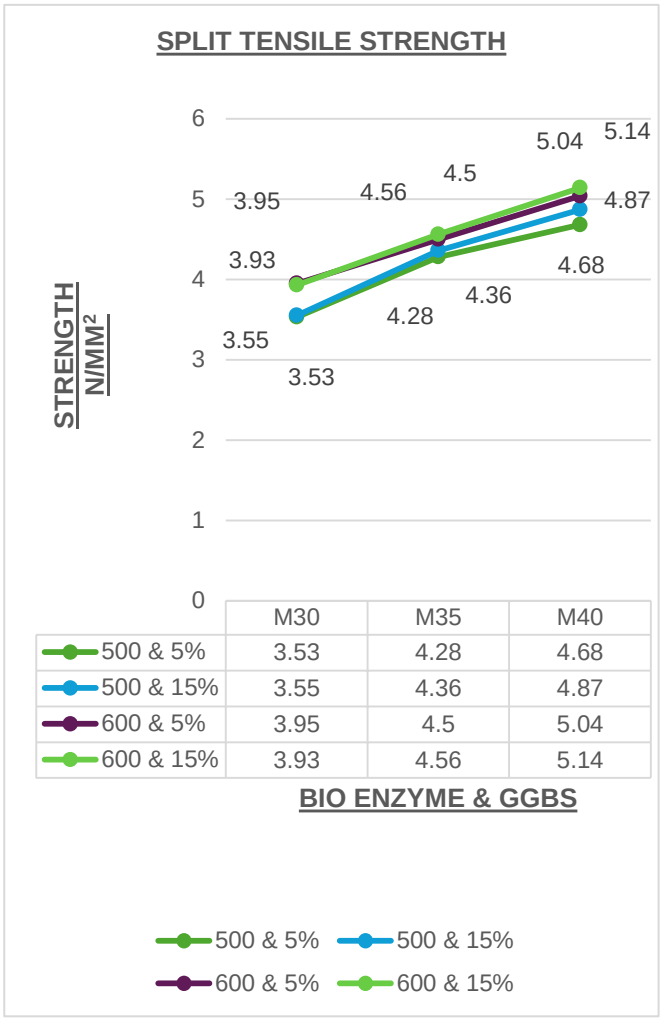


Chart -5: Split Tensile Test Result for 28-days

3.4 Durability Test Results

- To perform this test, 3% by volume of hydrochloric acid was combined with regular drinking water.
- The concrete cubes measuring 150mm were poured and allowed to cure for a duration of 28 days.
- Upon completion of the 28 days of curing for the specimens, the surfaces of the cubes were cleaned and weighed. The specimens were then submerged in an HCL acid solution.

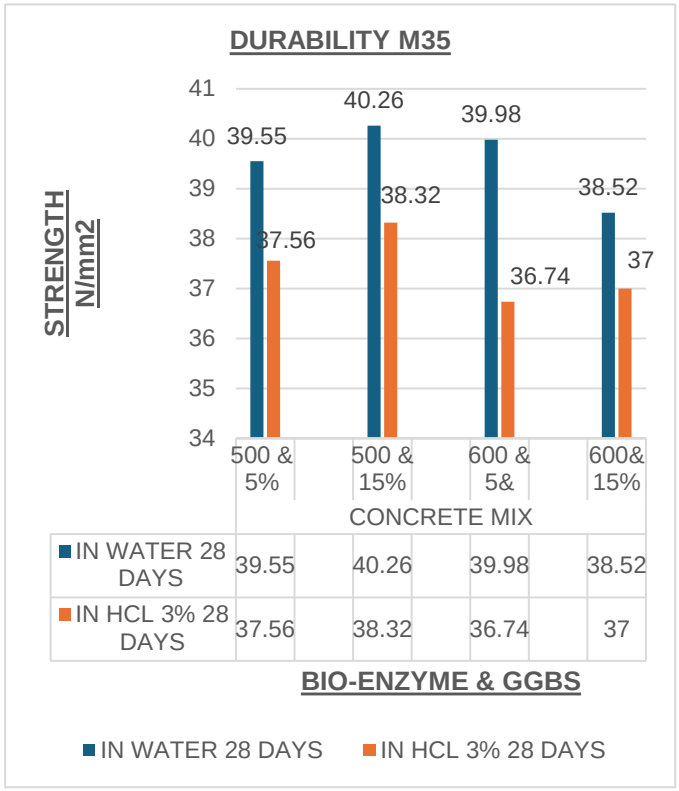


Chart -6: Durability Test Result for 28-days(M30)

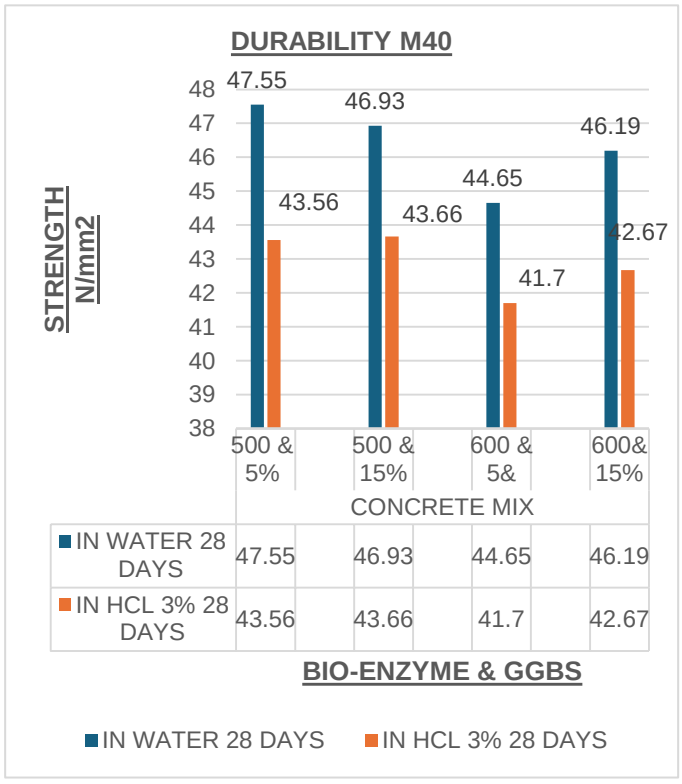


Chart -7: Durability Test Result for 28-days (M35)

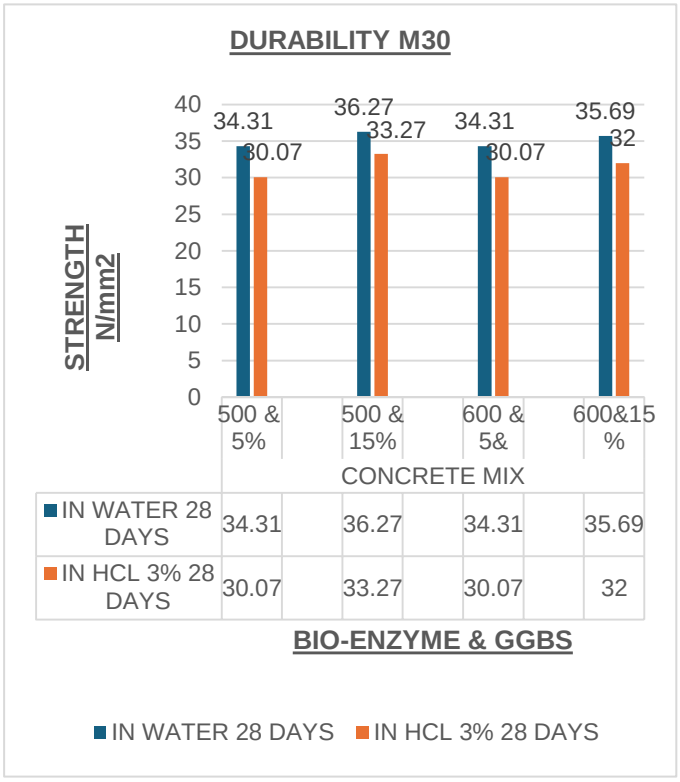


Chart -8: Durability Test Result for 28-days(M40)

4. CONCLUSIONS

- It is observed that there is increase in workability (Slump test) for the M30, M35 and M40 grade of Concrete treated with 600 ml/m3 with 15% dosage of Bio-Enzyme & GGBS respectively when compared to untreated concrete.
- It is observed that there is increase in strength by 7.39 % & 7.56 % & 3.52 % for the M30 & M35 & M40 grade of concrete treated with optimum dosage of Bio-Enzyme & GGBS with ageing when compared to untreated concrete.
- The split tensile strength of concrete continues to rise, reaching increments of 2. 61%, 10. 14%, and 16. 28% for the M30, M35, and M40 concrete grades, respectively, with the substitution of cement with Bio Enzyme and GGBS.
- It is observed that there is increase in strength rapidly at early stage treated with Bio-Enzyme & GGBS.
- In Durability test using HCL solution in concrete, Results shows that in normal M30, M35 and M40 grade of concrete maximum loss in strength is by 12.87%, 8.83%, 9.82%.
- Optimum dosage of Bio-Enzyme is 600ml/m3 with 15 % GGBS.

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